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(56) Documents Cited
GB 2267129 A   GB 1600721 A   EP 0288356 A1

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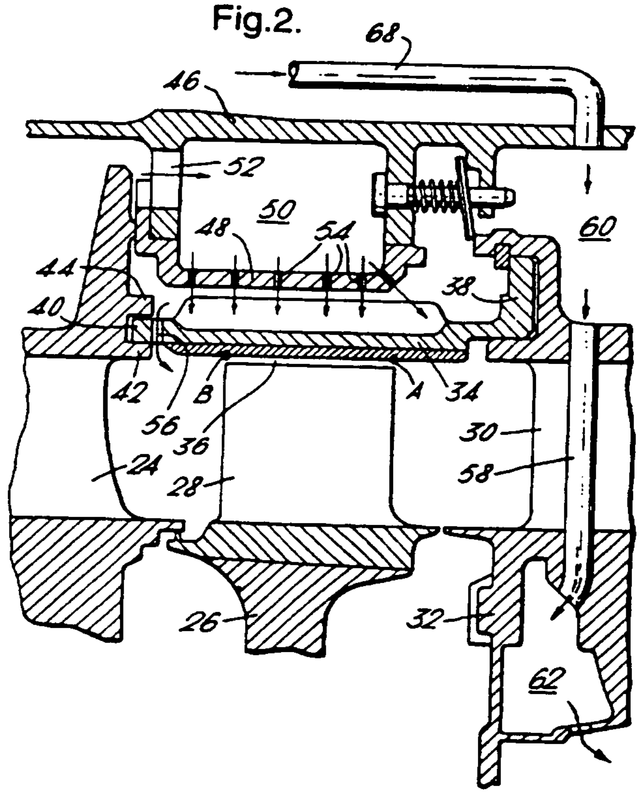
UK CL (Edition O) F1C CFPB, F1T TFDE
INT CL[6] F01D 11/00 11/08 11/14 11/24, F04D 29/08

(54) **Turbine and compressor rotor shroud clearance adjustment**

(57) Shroud segments 34 associated with radial rotor blades 28 are supported on a bladed stator disc 32 onto which air is directed to control its temperature and thereby the clearance between the rotor blades and the shroud segments. The air may be from a gas turbine engine compressor section (14,Fig.1) or hot air and the flow may be controlled by a valve (70) dependant on engine operating conditions. The shroud segments may be suspended from the mid section of levers pivoted on the stator disc rather than supported directly on the disc.

Fig.2.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

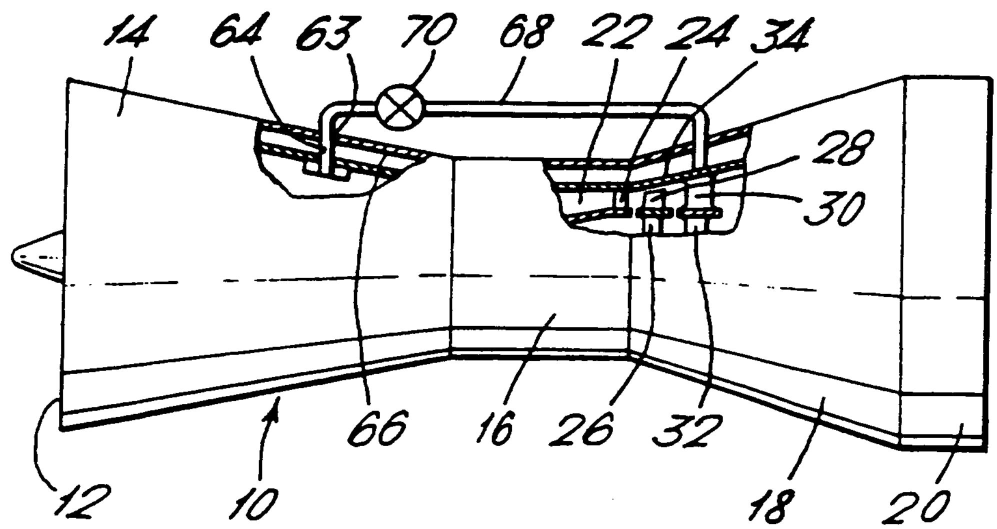
14
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Fig.3.

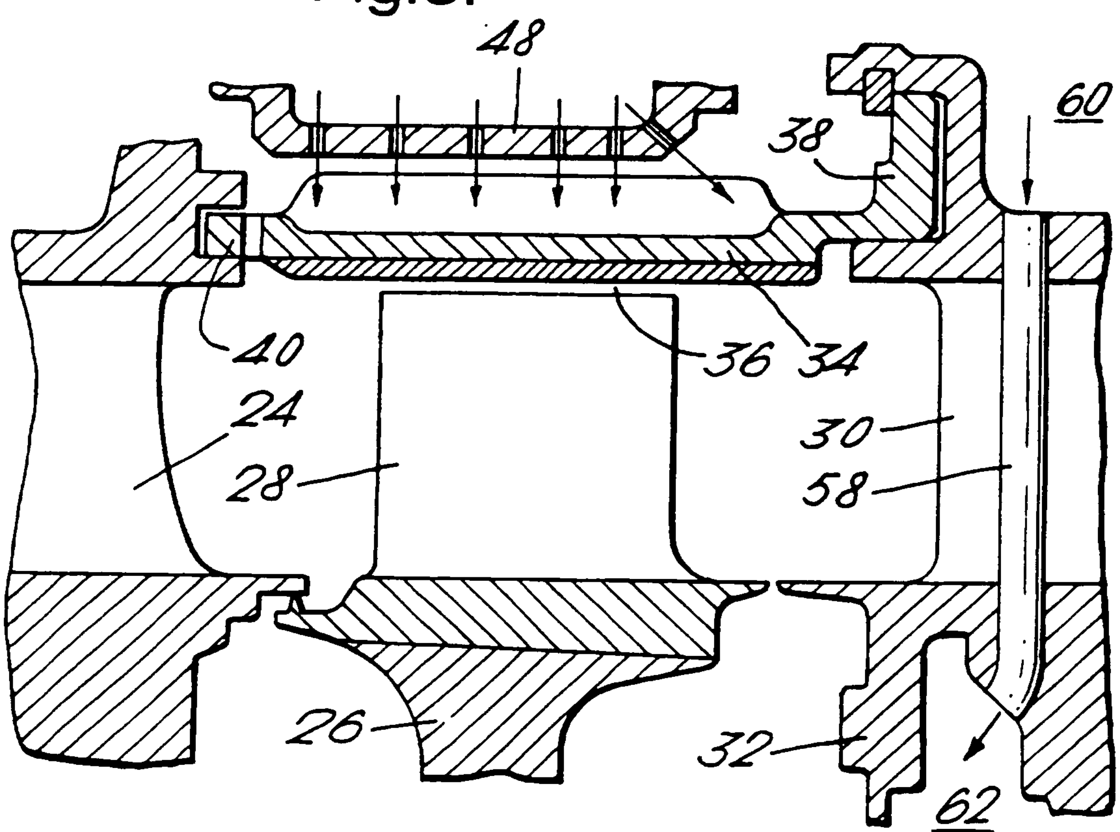
48
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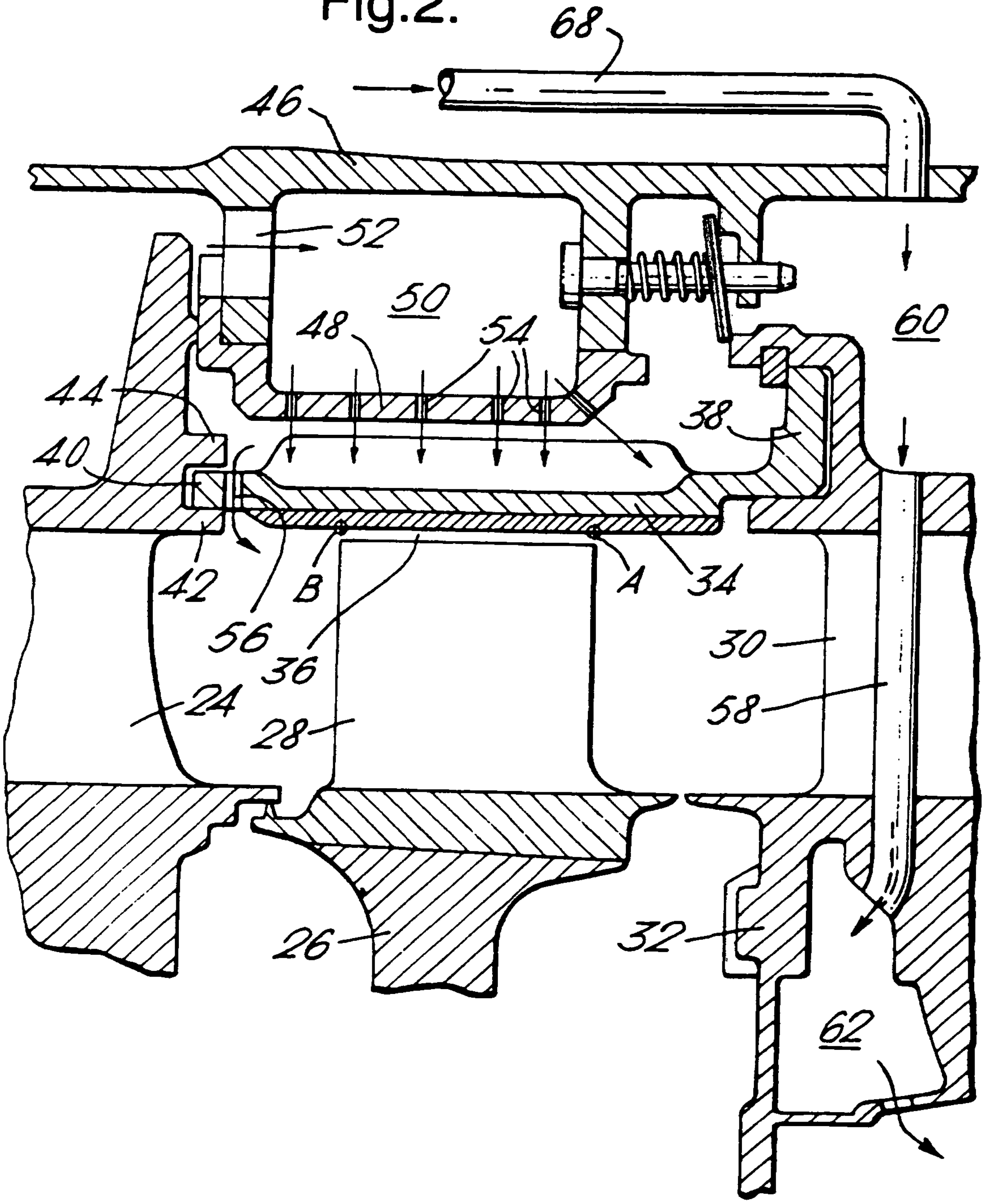
Fig.2.



A TURBOMACHINE

The present invention relates to turbomachines, particularly to gas turbine engines, more particularly to apparatus for controlling the clearance between rotor blades and a surrounding shroud of gas turbine engine compressors or rotors.

In order to increase the efficiency of turbomachines it is well known to maintain the closest possible clearance between the rotor blades and the surrounding shroud to ensure that very little of the working fluid passes through the clearance.

It is well known to have increased clearance between the rotor blades and the surrounding shroud to ensure that the rotor blades do not rub on the shroud during transient conditions or during violent manoeuvring of an aircraft to which the gas turbine engine is secured.

The present invention seeks to provide a turbomachine with novel apparatus for controlling the clearance between the rotor blades and a surrounding shroud.

Accordingly the present invention provides a turbomachine including a rotor having a plurality of radially extending rotor blades, on one side of the rotor a stator assembly including a stator disc and a plurality of stator vanes extending radially from the stator disc, shroud means supported from the stator assembly and encircling the rotor blades at a radial clearance therefrom, and fluid supply means arranged to supply fluid to th stator disc in order to influence the temperature of the disc and thereby control a radial

clearance between the tips of the rotor blades and the shroud means.

Preferably the stator disc and the stator assembly supporting the shroud means are located downstream of the rotor blades.

Preferably the shroud means is cantilevered from the stator assembly.

Preferably the shroud is located between inner and outer radial stops to limit radial movement.

Preferably the stops are carried on an adjacent stator assembly.

Preferably the fluid supply means comprises at least one passage extending radially through the stator assembly.

Preferably the fluid supply means is directed by the fluid supply means to impinge on the stator disc.

The fluid supply means may include means for modulating the supply of fluid influencing the temperature of the stator disc, which means preferably comprises valve means.

Preferably the fluid supply means includes valve means arranged to control the supply of fluid influencing the temperature of the stator disc.

Preferably the valve means is arranged to supply fluid to cool the stator disc to tend to reduce the radial clearance between the shroud and the rotor blades during cruise operation and to terminate the supply of cooling

fluid to tend to increase the radial clearance during high speed operation of the turbomachine.

The fluid supply means includes means for bleeding fluid from the compressor of a gas turbine engine.

The present invention will be more fully described by way of example with reference to the accompanying drawings in which:

Figure 1 is a partially cut away view of a gas turbine engine according to the present invention showing a turbine section,

Figure 2 is an enlarged cross-sectional view through the turbine section of the gas turbine engine shown in Figure 1 and

Figure 3 is enlarged cross-sectional view through the turbine portion of the gas turbine engine of Figure 1 showing an alternative embodiment.

A gas turbine engine turbomachine 10 is shown in Figure 1 and comprises in flow series an intake 12, a compressor section 14, a combustion section 16, a turbine section 18 and an exhaust nozzle 20. The compressor section 14 is arranged to be driven by the turbine section 18 and the compressor section 14 may comprise one or more compressor rotors (not shown) driven by one or more turbine rotors 26 via shafts (not shown). The gas turbine engine 10 operates quite conventionally in that air is compressed as it flows through the compressor section 14 to the combustion section 16. Fuel is injected into a combustion chamber 22 in the combustion section 16 and is burnt in the air supplied by the compressor section 14 to produce hot gases. The hot gases flow out of the

combustion section 16 through the turbine section 18 and exhaust nozzle 20 to atmosphere. The hot exhaust gases drive the turbine section 18 which in turn drives the compressor section 14.

The turbine section 18 comprises a high pressure nozzle guide vane assembly including an annular array of vanes 24 between which the hot exhaust gases from combustion chamber 22 flow to the turbine section. A high pressure turbine rotor 26 is located downstream of the nozzle guide vanes 24, and carries a plurality of circumferentially arranged, radially extending turbine blades 28. Downstream of the turbine blades 28 is located a low pressure nozzle guide vane assembly including an annular array of vanes 30, arranged circumferentially around and extending radially from a low pressure stator disc 32. A shroud means comprising an annulus of shroud segments 34 in end-to-end abutment encircling and spaced from the tips of the high pressure turbine blades 28 by a radial clearance 36. The downstream side 38 of each of shroud segments 34 is cantilevered from the adjacent low pressure nozzle guide vanes 30 while its upstream side 40 is located between two radial stops, radial inner stop 42 and radial outer stop 44 carried on the adjacent high pressure nozzle guide vanes 24.

A casing 46 encircles the nozzle guide vanes 24 and 34 and the shroud 34, and together with a member 48 defines an annular plenum chamber 50 which receives cooling air via supply apertures 52. The member 48, located immediately surrounding the shroud segments 34, is provided with a plurality of holes 54 to allow air within the chamber 50 to be expelled in the direction of the shroud 34 to provide impingement cooling of the shroud 34. Used impingement cooling air is exhausted through

further apertures 56 in the shroud 34 into the gas stream flowing through the turbine section 18.

The low pressure nozzle guide vanes 30 are provided with one or more passages 58 which extend radially through the low pressure nozzle guide vanes 30. These passages interconnect a second plenum chamber 60 defined between the casing 46 and the low pressure nozzle guide vanes 30 with a further chamber 62 defined between the stator disc 32 and the low pressure nozzle guide vanes 30.

The chamber 60 is connected to a bleed means 63 in the compressor section 14 of the gas turbine engine 10. The bleed means 63 comprises a plurality of apertures 64 formed in the casing 66 of the compressor section 14 thereby allowing air to be bled from the compressor section 14. The position of the apertures 64 in relation to the compressor stages is chosen to provide air at a suitable pressure and temperature. This air is supplied to the chamber 60 via a pipe 68 and a flow modulating means 70.

The passages 58 in the low pressure nozzle guide vanes 30 are preferably arranged to discharge the cooling air in a plurality of jets which impinge directly upon the stator disc 32 for maximum cooling effect, ie perpendicular to the stator disc surface. Alternatively the cooling air jets from the passages 58 may be directed with a radial or circumferential component to flow across the face of the stator disc 32.

The flow modulating means 70 may comprise a two-position on/off valve which preferably is operated by the engine or an aircraft control system. For example the rate of change of throttle, fuel flow, or other aircraft control demand is monitored and used to change the state of the

valve 70. Alternatively the pilot could switch the position of the valve 70. In another embodiment the flow modulating means comprises a valve adapted for progressive opening thereby providing continuously variable control of the cooling flow.

In operation, for maximum fuel efficiency, the valve 70 is opened to allow cooling air to be bled from the compressor section 14 through the pipe 68 to the chamber 60. The cooling air then flows from chamber 60 through the passages 58 in the low pressure nozzle guide vanes 30 into the chamber 62. Cooling air discharged from the passages 58 is directed against, or over, the stator disc 32, cooling it and reducing its diameter, which in turn causes the low pressure nozzle guide vanes 30 to be moved radially inwardly. This radially inward movement of the low pressure nozzle guide vanes 30 causes the shroud 34 to move radially inwards thereby reducing the clearance 36 between the shroud 34 and the rotor blade 28 tips. The valve 70 is operated for example during cruise conditions of an aircraft when the speed of rotation and temperatures of the engine remain relatively constant.

For reducing the possibility of tip rubs between the turbine blade 28 tips and the shroud 34, the valve 70 is closed to prevent cooling air flowing from the compressor section 14 to cool the stator disc 32. The hotter stator disc 32 increases in diameter with corresponding radial outward movements of the low pressure nozzle guide vanes 30 and shroud 34 to increase the clearance 36 between the shroud 34 and the rotor blade 28 tips. The valve 70 is closed for example during transient conditions and violent manoeuvring of the aircraft. In the case of a progressively opening valve the continuously variable control provided will lie between the limits of a fully open and a fully closed valve.

For example with a cooling flow of air to the arrangement shown in Figure 2 it is expected that this will provide a 0.4mm reduction in diameter of the stator disc 32, a 0.5mm reduction in clearance at the trailing edge of the turbine blade at point A, and a 0.59mm reduction in clearance at the leading edge of the turbine blade at point B. This gives most movement at the leading edge of the turbine blade 28.

In Figure 3 the shroud segments 34 are cantilevered from its upstream 40 on the high pressure nozzle guide vanes 24 giving most movement at the trailing edge of the turbine blade 28.

In a further embodiment the shroud segments 34 may be cantilevered from the low pressure nozzle guide vane assembly or high pressure nozzle guide vane assembly. Movement of the segments is controlled by suspending them from the mid section of levers pivoted on either the high pressure nozzle guide vanes or on the low pressure nozzle guide vanes. With an arrangement of this kind tilting of the shroud segments is avoided and the over-tip clearance is changed uniformly at all points between the shroud and rotor blades. A similar arrangement is described in GB Patent No 2,267,129.

Although the invention has been described with reference to gas turbine engines it may be equally applicable to other turbomachines. The invention may also be applicable to compressors of gas turbine engines, and it may be possible to supply hot air or fluid to the stator disc to increase the clearance to prevent rubs and not to supply hot air during cruise conditions.

CLAIMS

1 A turbomachine including a rotor having a plurality of radially extending rotor blades, on one side of the rotor a stator assembly including a stator disc and a plurality of stator vanes extending radially from the stator disc, shroud means supported from the stator assembly and encircling the rotor blades at a radial clearance therefrom, and fluid supply means arranged to supply fluid to the stator disc in order to influence the temperature of the disc and thereby control a radial clearance between the tips of the rotor blades and the shroud means.

2 A turbomachine as claimed in claim 1 in which the stator disc and the stator assembly supporting the shroud means are located downstream of the rotor.

3 A turbomachine as claimed in claim 1 or claim 2 in which the shroud means is cantilevered on one side from the stator assembly.

4 A turbomachine as claimed in claim 3 in which an opposite side of the shroud is located between inner and outer radial stops to limit radial movement of the shroud.

5 A turbomachine as claimed in claim 4 in which the inner and outer stops are carried on an adjacent stator assembly.

6 A turbomachine as claimed in any preceding claim in which the fluid supply means comprises at least one passage extending radially through the stator assembly.

7 A turbomachin as claimed in claim 6 in which fluid is directed by the fluid supply means to impinge on the stator disc.

8 A turbomachine as claimed in any preceding claim in which the fluid supply means includes means for modulating the supply of fluid influencing the temperature of the stator disc.

9 A turbomachine as claimed in claim 8 in which the means for modulating the supply of fluid comprises valve means.

10 A turbomachine as claimed in claim 9 in which the valve means comprises an on/off valve arranged so the fluid supply is "on" in a first mode of turbomachine operation and is "off" in a second mode of turbomachine operation.

11 A turbomachine as claimed in claim 9 in which the valve means is adapted for progressive opening.

12 A turbomachine as claimed in claim any of claims 8 to 11 in which the means for modulating the supply of fluid is open during cruise operation to supply fluid to cool the stator disc to tend to reduce the radial clearance between the shroud and the rotor blades and is closed during high speed operation of the turbomachine to terminate the supply of cooling fluid to tend to increase the radial clearance.

13 A turbomachine as claimed in any preceding claim in which the turbomachine is a gas turbine engine.

14 A turbomachine as claimed in claim 13 in which the rotor assembly is a turbine rotor and the stator assembly is a turbine stator.

15 A turbomachine as claimed in claim 14 in which the fluid supply means includes means for bleeding fluid from the compressor of the gas turbine engine.

16 A turbomachine substantially as hereinbefore described with reference to and as shown in Figures 1 and 2 of the accompanying drawings.

17 A turbomachine substantially as hereinbefore described with reference to and as shown in Figure 3 of the accompanying drawings.

The Patent Office

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Application No: GB 9602842.8
Claims searched: 1-17

Examiner: Roger Dennis
Date of search: 21 May 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): FIC CFPB F1T TFDE

Int Cl (Ed.6): F01D 11/00 11/08 11/14 11/24 F04D 29/08

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2267129 A (ROLLS-ROYCE)	1
A	GB 1600721 (GENERAL ELECTRIC)	1
A	EP 0288356 A1 (S.N.E.C.M.A.)	1

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.